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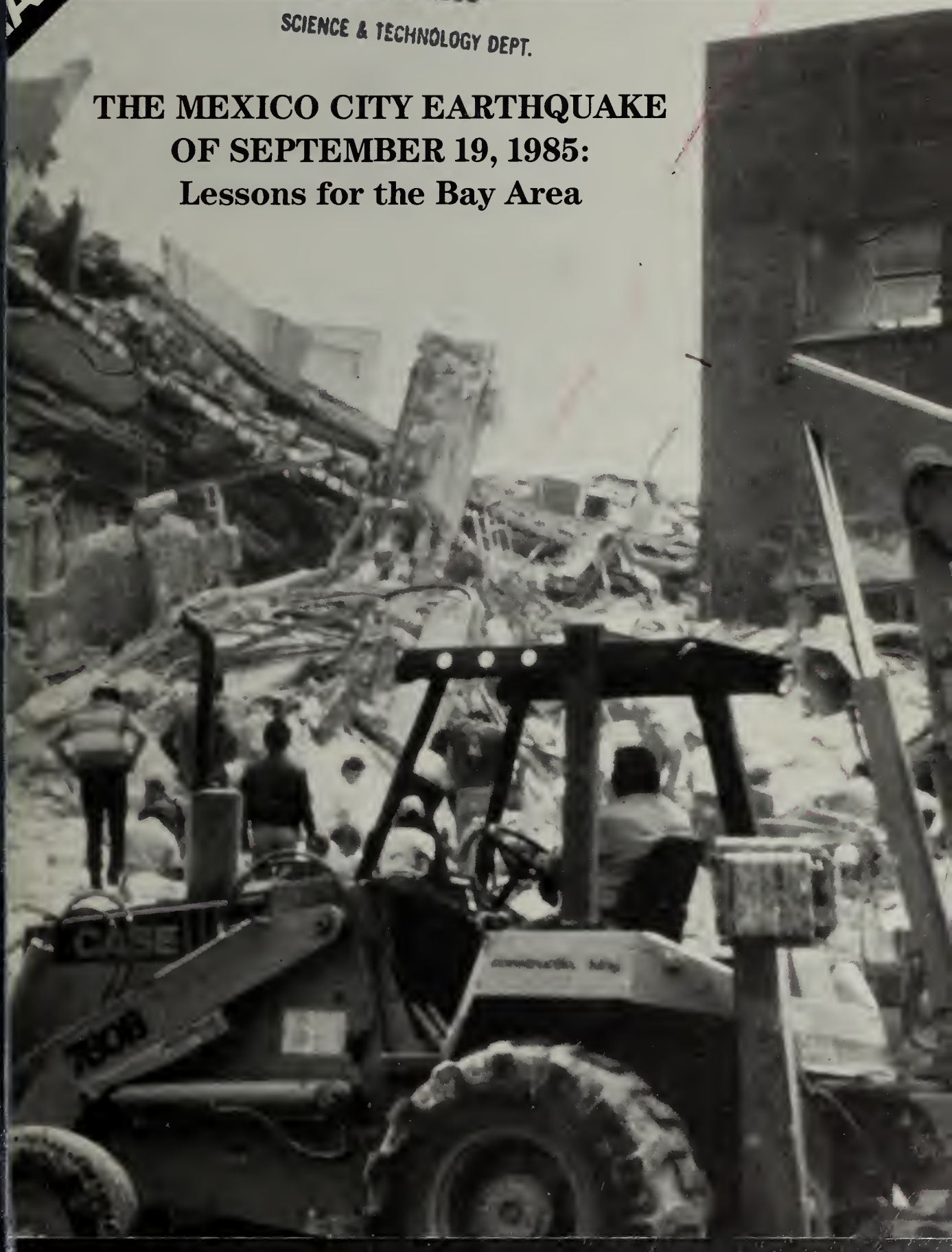
THE MEXICO CITY EARTHQUAKE OF SEPTEMBER 19, 1985: Lessons for the Bay Area



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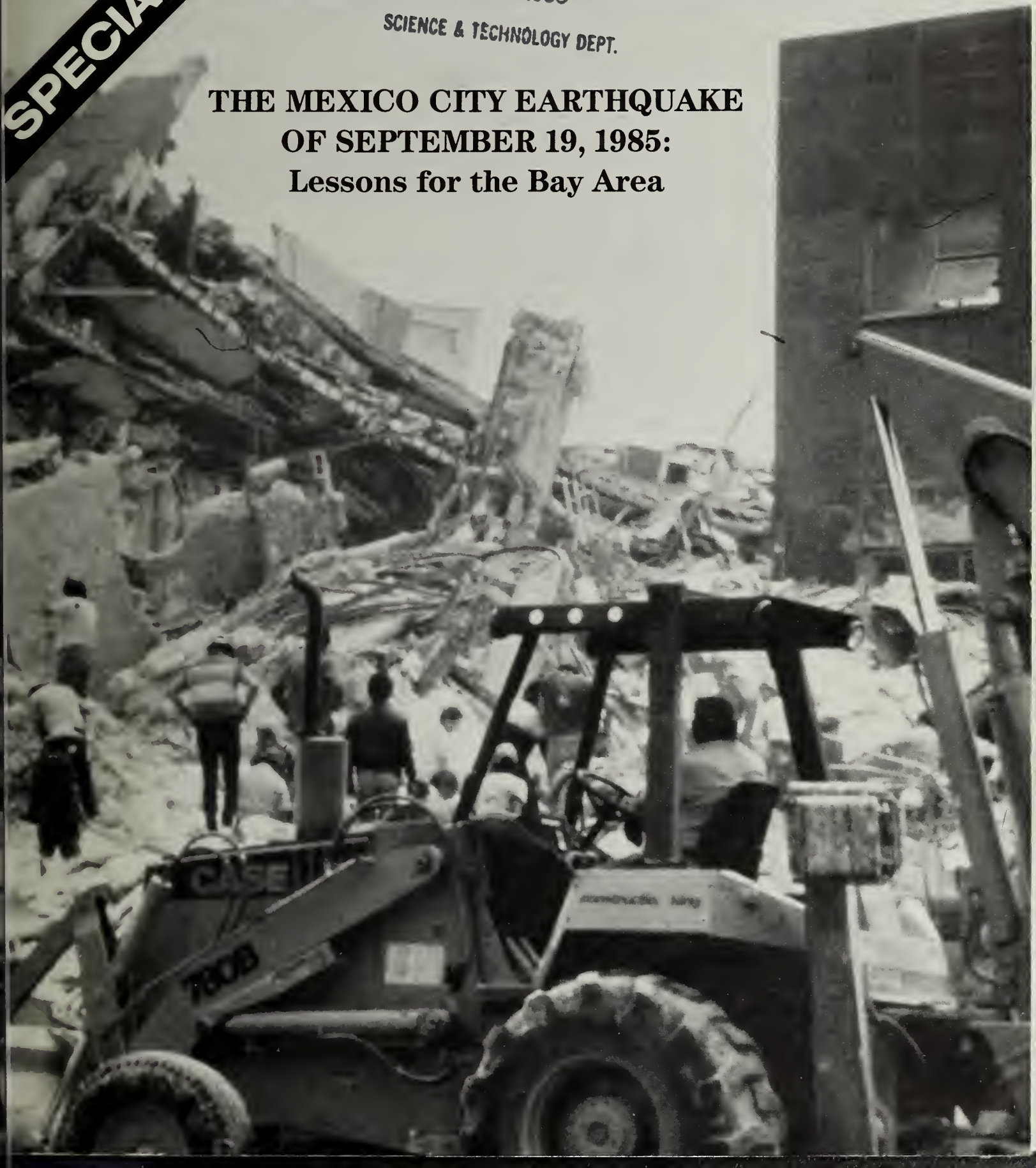
SPECIAL ISSUE

THE MEXICO CITY EARTHQUAKE OF SEPTEMBER 19, 1985: Lessons for the Bay Area



Message from the Director:

The tragedy of the Mexico City earthquake reminds us once again of the risks that we live with in California and the potential impact that an earthquake will have on the Bay Region.

In the aftermath of the earthquake, teams of seismologists, geologists, engineers, architects and social scientists converged on Mexico City to study the impact of the disaster and to present the lessons learned there to policy makers in the United States. Researchers found a striking number of similarities between the patterns of land use development and construction practices of our two countries that were alarming to Bay Area planners and engineers. The disruption of communication, difficulties in obtaining an accurate assessment of damage, and the complexity of disaster management provided vivid lessons for us.

The researchers were also reminded of the greater vulnerability to damage and disruption that the Bay Area faces. While the Mexico City earthquake epicenter was located on a fault more than 250 miles from the city, the Bay Area is literally crisscrossed by at least 9 earthquake faults; an earthquake on any one of which could cause extensive damage. Many utility systems and transportation routes cross the Bay Area's faults, posing the potential for damage to water, sewer, telephone, power, and transportations systems that Mexico City did not encounter.

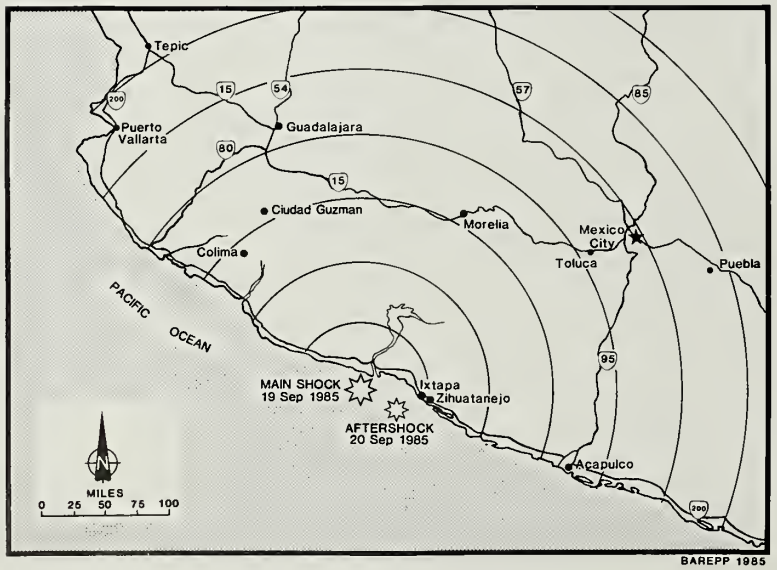
The unique geography of the Bay Region, resulting in populated peninsulas separated by the San Francisco Bay also creates the potential for isolation of populations and disruption of transportation and communication not experienced in Mexico. Difficulties and delays of the type experienced by Mexico would be greatly compounded if the bridges were damaged or freeways and overpasses impassable.

While there were only a few fire outbreaks in the aftermath of Mexico's earthquake, a parallel should not be drawn about the potential for fire in California's cities. The large amounts of combustible materials used in American construction and the presence of piped gas supplies to most residences and commercial buildings creates a potential for fire that did not exist in Mexico. The threat of fire as well as hazardous materials spills after even a moderate earthquake remains a great concern to Bay Area emergency planners.

The Mexico City disaster is the first major earthquake to strike a highly urban metropolis. It has presented an unequaled opportunity to learn about the vulnerabilities of our own communities. We will be adding to the tragedy of Mexico City if we do not learn from this disaster and prepare for the earthquakes that will inevitably strike the Bay Region.

Richard K. Eisner

RICHARD K. EISNER
Director
Bay Area Regional Earthquake Preparedness Project



EPICENTERS OF SEPTEMBER 19 EARTHQUAKE AND SEPTEMBER 20 AFTERSHOCK, LOCATED OFF THE COAST OF MEXICO

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OAKLAND, CA 94607
(415)540-2713

EARTHQUAKE PREPAREDNESS CHECKLIST

NEIGHBORHOODS

L12

San Francisco Public Library

REFERENCE BOOK

Not to be taken from the Library

PREPAREDNESS AND MITIGATION:

- Have you appointed a Neighborhood Leader or Block Coordinator who will keep a
  borhood residents, skills and equipment?

  those persons in your neighborhood who may require special
  emergency?

  l a listing of tools, equipment and materials available in the
  including private sector resources?

  public education about earthquake preparedness through local
  papers and service clubs?

  l first aid, search and rescue, communications, firefighting and
  nent teams? Have these teams received adequate training?

  d self-help networks between neighborhoods through a skills bank?

  -established location where the injured can be treated, and
  emergency care resources can be collected and distributed?

  neighborhood's ham radio and CB radio operators?

  ed procedures for communicating with police, sheriff, fire and
  vices?

- Have you inventoried the number and types of mobile (RV) equipment?
- Have you familiarized local emergency services offices and volunteer organizations with your neighborhood plan?
- Have you informed everyone which radio station to listen to and where emergency equipment and supplies are kept?

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EARTHQUAKE PREPAREDNESS CHECKLIST

NEIGHBORHOODS

PREPAREDNESS AND MITIGATION:

- Have you appointed a Neighborhood Leader or Block Coordinator who will keep a record of neighborhood residents, skills and equipment?
- Have you identified those persons in your neighborhood who may require special assistance in an emergency?
- Have you developed a listing of tools, equipment and materials available in the neighborhood, including private sector resources?
- Are you promoting public education about earthquake preparedness through local neighborhood papers and service clubs?
- Have you organized first aid, search and rescue, communications, firefighting and damage assessment teams? Have these teams received adequate training?
- Have you developed self-help networks between neighborhoods through a skills bank?
- Do you have a pre-established location where the injured can be treated, and volunteers and emergency care resources can be collected and distributed?
- Do you know your neighborhood's ham radio and CB radio operators?
- Have you established procedures for communicating with police, sheriff, fire and emergency services?
- Have you inventoried the number and types of mobile (RV) equipment?
- Have you familiarized local emergency services offices and volunteer organizations with your neighborhood plan?
- Have you informed everyone which radio station to listen to and where emergency equipment and supplies are kept?

EMERGENCY RESPONSE:

- Do neighbors know to check in on immediate neighbors?
- Do neighbors know to check in with the Neighborhood Leader or Block Coordinator?
- Has everyone agreed to hang a white "flag" out after the earthquake to signal that everyone and everything is all right?
- Will neighbors automatically begin search and rescue, checking first on homes where no flags are displayed?
- Are volunteers available to
  - administer first aid to the seriously injured?
  - conduct initial damage assessments?
  - make a list of missing persons?
  - make a list of injured persons and identify medical needs? *(Note: if they require hospitalization, tag them in some way before transporting in case they become unconscious, and keep track of where the injured are sent)*
  - begin removal of rubble and other material which may block emergency response functions?
  - contain any wandering pets in a confined area?
  - identify those structures that pose potential hazards and post warning signs or cordon off?
- Is there a plan to set up a mobile/central communications center?
- Is there a plan to contact outside support services, report damages, request needed supplies, and offer skills and resources that are available?
- Do neighbors know to keep radio channels open and stand by for emergency information and instructions?
- Is there a plan to set up assistance centers for incoming evacuees?
- Are there procedures for water purification and alternative waste disposal systems?

RECOVERY:

- Is there a plan to work in cooperation with support organizations (public and private) during the recovery phase?
- Is there a plan to determine water needs for the neighborhood and identify nearby water resources?
- Are there procedures for referring residents to the local Disaster Assistance Center for help in rebuilding, relocating, and finding family members and friends?
- Will you provide updated status reports on damage to neighborhood residents?
- Are there plans to promote earthquake preparedness in the recovery and rebuilding phase?

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INTRODUCTION:

The earthquake of September 19, 1985 and its strong aftershock on September 20, jolted a wide area of Mexico damaging structures in the states of Mexico, Jalisco, Guerrero, Colima and Michoacan. In the coastal resort of Ixtapa highrise structures were evacuated. In Ciudad Guzman most of the town's unreinforced masonry housing was destroyed. However, the greatest damage and loss of life occurred 250 miles from the epicenter in the central sections of Mexico City, areas that had been developed on a drained lake bed, *(see illustration)* and significantly, areas that were extensively damaged during the 1957 Mexico City earthquake.

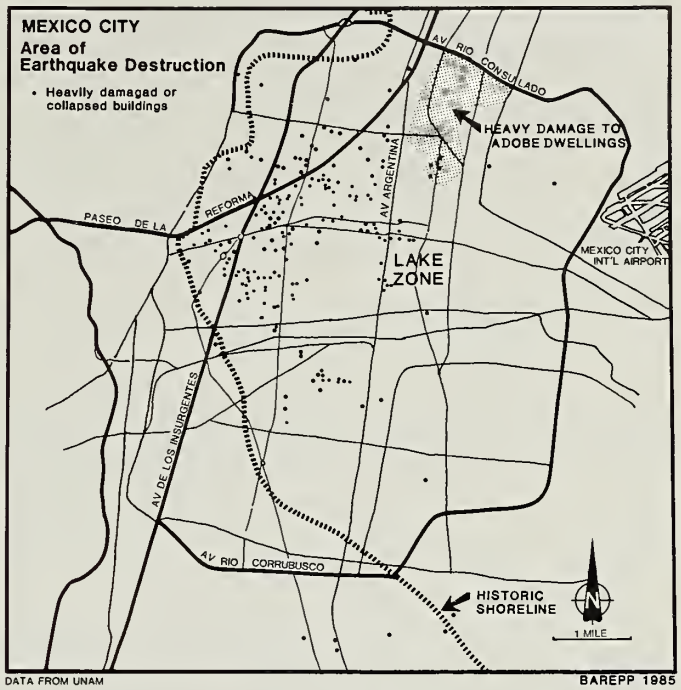
It is currently estimated by sources within the government that as many 23,000 people were killed in the earthquake and aftershocks. In addition, there were 30,000 injured and another 300,000 homeless. Most fatalities and injuries occurred in Mexico City, a sprawling metropolis of over 18 million.

More than 7000 structures were damaged; 265 collapsed, and an additional 775 were damaged so extensively they will require demolition. Damage estimates range from $4 billion in a report released by a United Nations agency to unofficial estimates as high as $10 billion.

Several factors explain the concentration of damage in the capital's older sections:

- The impacted areas are located on a historic lake bed containing deep sandy soils and clay deposits which appear to have amplified the intensity of the ground shaking and increased the duration of the shaking.

- The forces of the earthquake were creating lateral or sideways ground motions with a frequency such that a cycle was completed approximately every two seconds. This frequency corresponded with the natural frequencies of both the soils and many of the buildings constructed in the area, causing resonance in the structures. A parent pushing a child on a playground swing provides a good example of this type of resonance. Each push of the swing is quite small, but as the pushing continues, the child swings higher and higher. The small recurring ground motions had a similar effect on buildings.



MEXICO CITY LIES ON A PLATEAU AT 7,300 FEET ABOVE SEA LEVEL. THIS PLATEAU IS COMPLETELY ENCLOSED BY ANCIENT VOLCANIC PEAKS CREATING A BASIN IN WHICH LAYER UPON LAYER OF SOFT SEDIMENTS ARE TRAPPED. WHEN THE AZTECS FIRST VISITED THIS SITE, THE BASIN WAS PARTLY FILLED BY A LAKE. SPANIARDS LATER DRAINED THE LAKE AND PLACED FILL MATERIALS ON THE LAKE SEDIMENTS IN ORDER TO PROVIDE A FLAT BUILDING SURFACE. THE LAKE WAS NEVER PROPERLY DRAINED, AND THE FILL NEVER ENGINEERED PROPERLY. AS SEEN ON THE MAP ABOVE, DAMAGE IN MEXICO CITY DROPS OFF SHARPLY AND STABILITY OF THE SOILS INCREASES AS ONE MOVES AWAY FROM THE SHORELINE BECAUSE SOIL COMPACTION INCREASES AND WATER CONTENT DECREASES.

- Some of the buildings in the impacted area had settled three to four meters below their original street level due to ground water pumping and subsidence. It is likely that this potential for ground settlement resulted in many of the buildings in these districts being structurally damaged before the earthquake and prone to collapse.

- Many scientists and engineers have suggested that the duration of ground shaking was a major factor causing structural failure. Shaking in Mexico lasted nearly 60 seconds, much longer than many earthquakes. Structures were subjected to extremely large forces at a frequency that caused resonance for a very long period of time. Additionally, as a structure's individual elements weakened, this brought the building's vibration more and more into the harmonic motion of the earthquake. The cumulative effect of failure in building elements degraded a building's structural strength and resulted in collapse.

STRUCTURAL DAMAGE:

Structural failure accounted for the terrible toll associated with the Mexico earthquake. The building types most vulnerable to failure were unreinforced masonry structures (brick, concrete block and adobe) in older, central neighborhoods and reinforced concrete frame structures between four and fourteen stories in the downtown area. Resonance was a major factor in their collapse, but other factors also contributed significantly:

- *Building elements were not tied together adequately*

Unreinforced masonry buildings are inherently brittle, lack the ability to flex with earthquake motions and often disintegrate and collapse. Roofs and foundations poorly joined to the buildings resulted in walls separating from floors and roofs causing failure.

Several concrete frame buildings that collapsed appeared to fail at connections between columns and beams or where columns penetrated floor slabs.

- *A building's configuration affected its overall strength and response*

Buildings of non-symmetrical shapes in plan and elevation (including "U", "T" and "L" shaped buildings and buildings with tall open ground floors) were more prone to damage. Complex architectural designs appear to have resulted in a lack of symmetry and continuity in earthquake resisting structural elements. Many building failures were attributed to asymmetry of configuration and stiffness (strength).

- *Concrete frame buildings were stiffer in one direction than another*

In some concrete frame buildings the frame was in-filled with "non-structural walls" of unreinforced masonry, brick or tile. The combination of these very stiff walls along with the more flexible frame resulted in tortional or twisting movements in the buildings. Many collapsed structures confirmed this twisting mode of failure.

COLLAPSE OF THE NUEVO LEON APARTMENTS

Photo: C. Scawthorn

■ *Older buildings appeared to be more vulnerable to damage*

Most of the larger buildings damaged appear to have been built before 1976, many prior to 1942. In 1976 changes were made in the building codes of both Mexico and the United States that recognized the vulnerability of brittle concrete frame buildings during even moderate earthquakes. It is suspected that many of the damaged buildings also suffered damage in the earthquake of 1957. With the adequacy of structural repairs following the earlier event unknown, the cumulative effect of the two earthquakes could have caused many of the structural failures.

■ *There was inadequate separation between adjacent buildings*

Many buildings battered one another. Damage was especially devastating when tall, flexible buildings struck lower, stiffer buildings, resulting in fracture of columns and masonry in-fill property line walls.

■ *Changes in occupancy resulted in excessive floor loads*

Many medium rise buildings designed for office or residential uses had been converted for use in textile and garment manufacturing. Equipment and storage of materials greatly exceeded the weight that the floors were designed to withstand. This could have resulted in the frequent examples of "pancake type failure" of these structures.

■ *"Weak column, strong beam" construction contributed to failures*

Economy in the use of materials appears to have resulted in the construction of buildings with very slender and flexible columns with stronger, stiffer beams and spandrels. The earthquake's horizontal motions often put excessive force on the slender (weaker) columns, resulting in their failure. This problem was compounded when heavy masonry in-fill walls increased loading and restrained movement of these columns.

■ *Inadequate design, construction and maintenance of structures was evident*

The earthquake exerted forces up to four times those described by the building code minimum. Building code requirements and the quality of engineering in the United States and Mexico are comparable, but this earthquake demonstrated the need for earthquake engineering considerations beyond those required by building codes.

Inadequately or improperly repaired damage from the 1957 earthquake, alterations to structural and non-structural elements after construction of the building, inadequate inspection during construction to insure conformance with engineering design, and inadequate maintenance of structures all contributed to a lack of enough structural strength to resist the earthquake's forces.

■ *Extensive non-structural damage was a life threat hazard and interfered with response efforts*

Collapsed stairs, unreinforced masonry walls and partitions, heavy plaster finishes and masonry veneers, unbraced furnishings, light fixtures and ceilings all resulted in death and injury to building occupants. In addition, the search and rescue efforts were hampered by the amount and weight of debris that had to be removed to gain access to the building.

Photo: C. Scawthorn

STRUCTURAL DAMAGE:

LESSONS FOR THE BAY REGION:

- *Development and land use patterns will have an impact on the extent of damage and life loss from moderate or larger earthquakes.*

Areas of natural or manmade fill along the Bay margins and other areas of unconsolidated soils are likely to shake violently for a prolonged period of time, increasing the probability of structural damage and collapse. Land use policy, development regulations and building code provisions should recognize the increased risks to buildings in these areas.

- *Unreinforced masonry and older less flexible reinforced concrete frame buildings pose a threat to life during even moderate local or large distant earthquakes.*

Nearly every community in the Bay Region contains unreinforced masonry structures built before the introduction of seismic provisions to the building codes. In addition, older concrete frame buildings have been shown to experience extensive damage in moderate earthquakes. These structures should be identified and either strengthened, demolished, or their occupancies reduced to lessen the life threat they pose to occupants.

- *Local jurisdictions should strengthen their design review, code reinforcement and building inspection agencies to ensure that structures are not only properly designed, but also constructed according to design.*

Structural failures during recent earthquakes in California have pointed to a need for greater care in both the design and construction of new structures. Moderate sized earthquakes in El Centro, San Fernando and Morgan Hill resulted in unexpected damage to newer structures built to current codes.

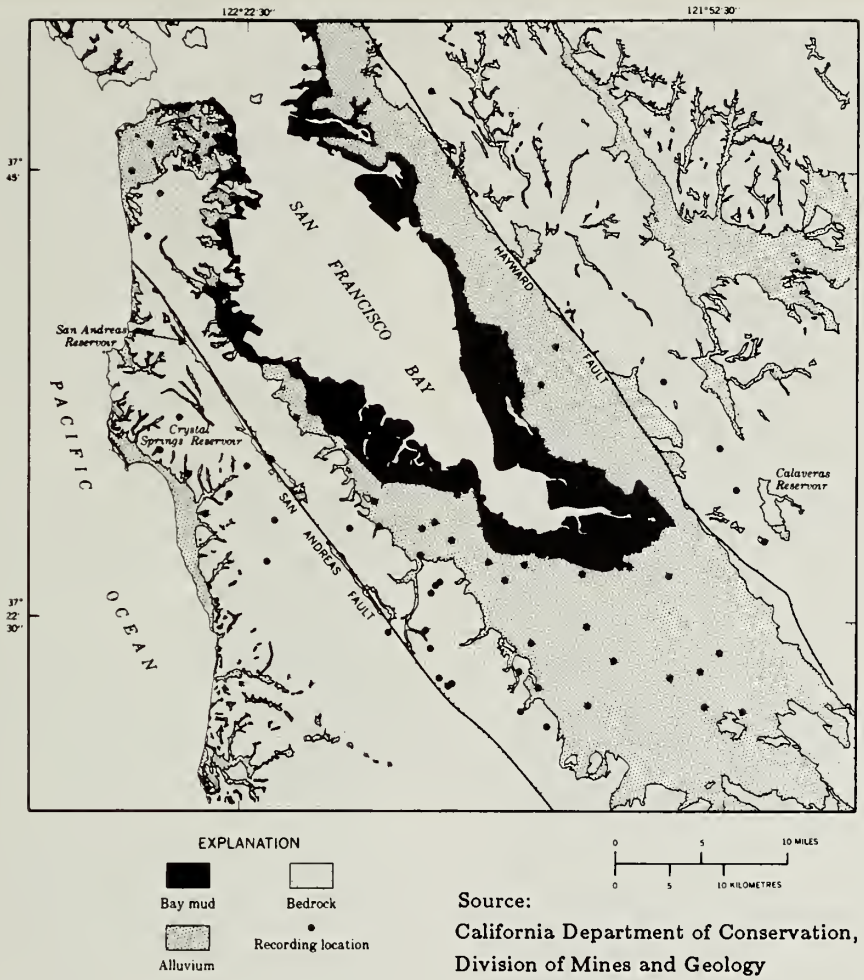
- *Non-structural damage can cause injury and impede rescuers*

Earthquakes in Mexico and California repeatedly demonstrate that collapsed partitions, ceilings, stairways and other non-structural building elements cause injury, death and delay rescue attempts. Such non-structural elements should be designed to withstand expected earthquake forces.

BAY AREA JURISDICTIONS NEED TO ASK THEMSELVES:

- Is there coordination between the planning and building departments in land use and development decisions?
- Does the jurisdiction know the location of its hazardous buildings?
- Is there a plan to reduce the hazards posed by such buildings?

GEOLOGY:



Source:
California Department of Conservation,
Division of Mines and Geology

THE FLATLAND AREAS SURROUNDING SAN FRANCISCO BAY HAVE STRIKING SIMILARITIES TO THE DAMAGED AREA OF MEXICO CITY. THE BAY IS AN ELONGATE TROUGH INTO WHICH YOUNG SEDIMENTS ARE BEING DEPOSITED. IN ADDITION MUCH FILL SOMETIMES POORLY ENGINEERED, HAS BEEN PLACED IN THE BAY MARGIN SINCE GOLD RUSH DAYS. BENEATH THE FILL ARE WATER SATURATED CLAYS CALLED BAY MUD. THIS AREA, INDICATED IN BLACK, IS EXPECTED TO SHAKE WITH THE GREATEST INTENSITY DURING AN EARTHQUAKE.

LIQUEFACTION, WHICH WAS NOT A MAJOR PROBLEM IN MEXICO CITY, COULD POSE PROBLEMS FOR THE BAY MARGINS. LIQUEFACTION IS A PHENOMENON AFFECTING LOOSELY CONSOLIDATED, SATURATED, SANDY SOILS DURING AN EARTHQUAKE. SHAKING CAUSES THE SOILS TO LOSE STRENGTH AND FLOW LIKE A LIQUID. STRUCTURES BUILT UPON THESE LIQUEFIABLE SEDIMENTS WOULD SUSTAIN SERIOUS FOUNDATION DAMAGE.

MEXICO CITY CONFIRMED THE LIKELIHOOD THAT AREAS CONTAINING SANDY, ALLUVIAL-TYPE SOILS WILL BE THE AREAS MOST PRONE TO VIOLENT GROUND SHAKING. BAY AREA DECISION MAKERS NEED TO PONDER THESE QUESTIONS:

-Should we rethink our land use policies for future development in the immediate Bay periphery?

-Should we study more closely the "resonant frequency" of Bay Mud?

-Will Bay Mud react in the same ways during an earthquake as the clays in Mexico City? (The general feeling among soils engineers is that it will not perform as poorly as the lake bed sediments. However, those areas where fill has been placed on top of Bay Mud are, at best, questionable).

MANAGEMENT OF EMERGENCY RESPONSE:

The Mexico City earthquake confirmed what we have learned from other disasters, and what we continually learn when we plan and conduct earthquake exercises. The most common problems in emergency management revolve around information -- obtaining critical emergency information (disaster intelligence, damage assessment); getting that information to those who need it (communications); and using that information to set priorities and direct emergency response activities based on predetermined roles and responsibilities (coordination, disaster management). In addition, two aspects of the emergency response in Mexico - search and rescue and the use of volunteers - highlighted particularly useful lessons for the Bay Area and are discussed in more detail in the following sections.

DISASTER MANAGEMENT

The responsibility for disaster planning and response in Mexico lies with the military. There is currently no civil government or public agency with assigned roles or responsibilities for disaster management. The existing military plan (DN-III3) gives full power to the military in the disaster area, and as such was not feasible for use in the Federal District of Mexico City. The military did have a visible presence in Mexico City after the earthquake, and played a limited role in public safety and property protection. The DN-III3 plan was used in all other impacted areas outside of the Federal District without incident.

Since it was inappropriate to use the DN-III3 plan in the Federal District of Mexico City (DDF), the result was improvisation on a grand scale. After the first day the President placed the Regent (Mayor) in charge. The Regent then established an Emergency Operations Center in the National Palace, which functioned as a central point of information. Coordination was difficult, however, because of the transition of responsibility from military to civilian authorities and the fact that many government buildings either collapsed or were significantly damaged. Individual public agencies acted independently to respond as best they could based on their normal day to day responsibilities. Responsibility at different damage and rescue sites changed through time.

Immediately after the earthquake there was no standard method for assessing the damage or recording the information. This led to a great deal of confusion as well as a lack of credible information presented to the public. In some cases information was collected via foot, cycle, or automobile drive-by. Additional information was provided through individual and voluntary organizations. The government, as well as the city's population, was getting situation reports from the media coverage. Pay phones were converted for free use which facilitated reporting damage.

The single frequency available for police and fire communications was quickly overloaded, contributing to the communication problems.

Helicopters, which are generally thought to be a primary source of disaster intelligence, were not only ineffective in the Mexico City earthquake but posed a threat to public safety. From the air it was extremely difficult to evaluate the extent of damage to structures. This was particularly true in the case of the extensive "pancaking" and partial collapse of buildings. In addition, it was feared that the vibration and strong winds caused by the helicopter blades posed threats to buildings already seriously damaged and to the victims trapped in them.

EMERGENCY SHELTER

Nearly 2% of the city's population lost their homes in the earthquake, creating an immediate problem of emergency shelter. However, the earthquake confirmed a lesson learned in previous disasters: people use the extended family and friends network as much as possible, and underutilize the official mass care facilities. According to some estimates more than 50% of those forced to evacuate their homes moved in with friends or relatives. Also, particularly in the lower income neighborhoods, people preferred to remain near their damaged homes and household possessions. Many private voluntary organizations set up "unofficial" shelters in the neighborhoods, to supplement the efforts of individual residents.

Sanitation was reportedly a major problem in the mass care facilities. The toilets, sewers and water systems in the shelters were quickly overloaded, resulting in raw sewage spills and additional health and sanitation problems.

MEDICAL CARE

Health Services was one of the most seriously affected sectors in the Mexico City earthquake. The damage was of national significance, since the country's major care and teaching hospitals were centralized in the capital. Hundreds of patients, doctors, nurses and medical interns lost their lives in the massive collapse of the Benito Juarez hospital. A total of nine hospitals and clinics collapsed, causing the loss of more than 25% of all hospital beds in the capital.

Despite the extent of damage a number of sources reported that emergency medical attention was readily available for all the injured. Domestic and foreign volunteer medical teams provided first aid at the collapse sites as trapped victims were being rescued. In many cases there were too many medical personnel to be effectively utilized. Many medical volunteers therefore moved to the shelters and neighborhoods, where they established mobile clinics to treat minor injuries and shock. There was no shortage of medical supplies in Mexico City.

Many different agencies and organizations operate hospitals, clinics and ambulances for emergency assistance in Mexico, resulting in considerable overlap of services and responsibilities in the aftermath of the earthquake.

FIRE

Fire was not a major problem in Mexico City unlike the situation expected in the San Francisco Bay Area . Preliminary estimates indicate that 120 fires were reported on September 19th, 193 on September 20th, 38 on September 21st and 5 on September 22nd. The larger number on September 20th was caused by the large aftershock and the restoration of power. In a normal year Mexico City's fire department has 3000 runs; this compares to 30,000 runs per year in Los Angeles. Fire was not a major problem in Mexico City because there are no natural gas lines (bottled gas is the most commonly used fuel); the homes are built primarily of masonry; and people use fewer combustible materials in their homes.

VOLUNTEER ENGINEERS CAN HELP AFTER CALIFORNIA EARTHQUAKE

The Mexico City earthquake has pointed out the importance of fast, accurate damage assessments. California has a program to increase local governments' capability in making such assessments. The Structural Engineers Association of California (SEAOC) and the American Society of Civil Engineers (ASCE) in conjunction with the California Office of Emergency Services (OES) have developed a system to provide structural safety inspections of buildings and civil works after an earthquake. Members of these two organizations volunteer their time, and they are registered with and hold identification cards issued by OES. They work under the direction of local officials and provide safety inspections to determine if civil works (bridges, roads, utilities, etc.) and buildings are safe for continued use. Each team of two to five people completes a Structural Safety Assessment Report and recommends the posting of red, gold or green placards to indicate unsafe to enter, limited entry or no hazard found.

Local governments wishing to use these volunteer services to augment the probably overburdened local building officials should contact OES immediately after an earthquake.

Photo: J. Hayasaka

RESCUE WORKERS AT A COLLAPSED BUILDING

MANAGEMENT OF EMERGENCY RESPONSE:

CHECKLIST FOR BAY REGION RESPONSE

- Make sure all agencies that can offer assistance at the time of an earthquake disaster are involved in pre-event planning. This includes public, private and voluntary organizations that have special expertise, personnel or equipment.
- Establish clear roles and responsibilities for planners, responders, and managers.
- Consider the use of a coordinated command system to ensure an effective response at multiple sites.
- Be prepared to quickly assess the need for outside resources.
- Develop alternative strategies for damage assessment.
- Build redundancy into communications systems.
- Conduct pre-event discussions of multijurisdictional issues and potential problems.
- In emergency shelter or evacuation planning be realistic about the population's determination to stay near their homes, or preference for staying with families or friends.
- Make sure shelter facilities are equipped for the health and sanitation needs of large numbers of people.
- Ensure effective employee response through education and training.
- Develop effective techniques for coordination, training and use of volunteers.
- Recognize the positive role of the media in providing public information before, during and after the earthquake.

Search and Rescue

The need for urban search and rescue is one of the major lessons from Mexico City. The partial and complete collapse of reinforced concrete buildings trapped many people under heavy rubble. In the first few hours hundreds of people were pulled to safety, primarily by volunteers. Very little equipment was available in this initial period, and volunteers worked barehanded with chunks of concrete and rubble in a frantic effort to find victims. By the time specialized equipment began to arrive, including search and rescue teams from around the world, it was too late to save many of the trapped victims. According to presently available statistics, over 500 survivors were pulled from the rubble in the first day, whereas only slightly over 100 more were rescued during the next ten days. The large aftershock on September 20th also brought down some of the previously damaged structures, killing some of the people trapped inside. In addition, it has been estimated that more than 100 volunteer rescuers were killed because of further building collapse while they were working to find survivors. It has also been reported that numerous rescuers, as well as victims, suffered kidney damage from lack of water. Many rescue workers became too involved in the rescue effort to rest or stop for water or nourishment.

The rescue efforts were eventually supervised by the government. There was also a structural engineer or architect from Pemex (the government-owned oil company) on site in most cases, as well as numerous other experts who volunteered their services. The fact that no single agency had the training or responsibility for this type of search and rescue made it difficult to decide who should be in charge at individual sites. For example, at the collapsed Juarez Hospital site, hospital employees, the fire department, the police department and the military were all involved in the search effort at various points.

LESSONS FOR THE BAY REGION:

- *Volunteers will attempt search and rescue unaided before and even after help arrives.* Local jurisdictions need to develop plans to use volunteers in search and rescue activities. Authorities should recognize that individuals with relatives and friends trapped inside buildings will want to participate in rescue efforts and are a valuable resource in rescue efforts.

- *Care must be taken to provide for the health of rescue workers.* The physical health of the workers must be provided for during the rescue operation with particular attention paid to ensuring sufficient water as well as food. After the rescue operations are complete, psychological counseling should be available to workers to help them cope with their traumatic experiences.

- *Urban rescue involves different skills than are traditionally used in search and rescue.* Specialized equipment will need to be brought in, along with specially trained personnel. Individuals with a knowledge of structures, most likely structural engineers and architects, will need to be involved in decisions regarding how to enter collapsed buildings and decisions regarding which buildings could be searched first and most safely.

- *Urban rescue appears to allow a very short time during which many survivors may be found.* Needed equipment and expertise must be mobilized in the first 24 hours to save as many lives as possible. After that, the chance of finding survivors rapidly diminishes.

- *No single government agency currently is responsible for urban search and rescue.* This means that no agency is responsible for training personnel or acquiring equipment. The lack of identified responsibility and training can cost lives in future disasters.

BAY AREA JURISDICTIONS NEED TO ASK THEMSELVES:

- Has the search and rescue responsibility been delegated to a particular agency or department in the jurisdiction?

- Has that agency or department received training in urban rescue?

- Does the jurisdiction maintain a stockpile of small hand tools, picks, portable power concrete saws, gloves, high quality rope and batteries?

- Does the jurisdiction have a plan for acquiring heavy equipment and special expertise to assist in search and rescue?

- Is there a plan for using volunteers in an urban rescue effort?

- Is there a plan to provide for the physical and mental health of rescue workers?

The Role of Volunteers and Volunteer Organizations

One of the more heartening aspects of Mexico City's tragedy was the spontaneous outpouring of help from the youth of the city, as well as from neighbors and friends of all ages in the affected areas. One source estimated that more than 7000 volunteers spontaneously appeared at disaster sites. Without waiting for direction from the government, volunteers began working at collapsed building sites, driving rescue vehicles, and bringing needed supplies such as food, gloves, flashlights and blankets to the rescue sites. At some of the rescue sites neighborhood leaders became impromptu rescue organizers, directing the activity of volunteers.

MANAGEMENT OF EMERGENCY RESPONSE:

In addition to individual volunteers, voluntary organizations, such as the Red Cross, Salvation Army, and religious and philanthrophic organizations, played an important role in the response and recovery activities. International aid flowed through such organizations, and although in some cases inappropriate supplies were donated, overall the voluntary aid was useful. These organizations, both international and local, played a role in damage assessment, search and rescue, mass care and shelter and reconstruction. Through their own networks the organizations sent volunteers to search and rescue sites, and then provided tents and food to many of the homeless living in make-shift quarters in front of their ruined homes. Volunteer organizations are now involved in providing financial and material support in the rebuilding of housing, coordinating their efforts with those of the government.

LESSONS FOR THE BAY REGION:

- *Local jurisdictions need to consider ways of handling and effectively using volunteers after a damaging earthquake.* Have fire departments, for example, trained their personnel to use volunteers quickly and effectively? As in Mexico City, volunteers could be used to bring supplies to a neighborhood, to direct traffic, and to keep track of the injured.

- *Efforts should be made to coordinate government response efforts with the voluntary organizations that can play a critical role in response and recovery.* Such organizations should be encouraged to make a careful assessment of needed supplies, and to provide only items that are actually needed. Also, these organizations can play an important role in the training of their volunteers. For example, on the basis of their experience with the Mexico City earthquake, the Seventh Day Adventists (with 150,000 volunteers) have decided to give each volunteer a specific assignment for future disasters: cooking food, directing traffic, driving a rescue vehicle, etc. UNICEF in Mexico is also developing a training program on the use of volunteers.

BAY AREA JURISDICTIONS NEED TO ASK THEMSELVES:

- Does each first-responder agency have a plan to effectively use volunteers?
- Is there a plan to coordinate government response with the efforts of voluntary organizations?
- Do the voluntary organizations have assignments for their volunteers?

Photo: P. Schulz

DEBRIS REMOVAL AT THE SITE OF THE HOTEL REGIS

RECOVERY AND RECONSTRUCTION:

Mexico City has now begun the slow, difficult and very expensive process of rebuilding after the earthquake. Although this rebuilding is still in its early stages, several preliminary decisions have been made that will guide this process. It also appears that, despite the enormity of the disaster, this city of eighteen million people has managed to continue with day-to-day life.

■ THE RECONSTRUCTION COMMISSION

A National Reconstruction Commission was set up in October to plan for the many aspects of the recovery and rebuilding of Mexico City. The Commission has nine subcommittees with members from both the public and private sectors to provide advice on all facets of the reconstruction. However, there is some sense that after meeting two or three times most of these committees have fallen into disarray and some decision making may be proceeding outside the framework of these committees. In addition, the government is inviting groups to make presentations on their visions of future downtown development. The early priorities for rebuilding are hospitals, schools and housing in that order. All efforts have focused on those sectors. A one-half hour television program each day keeps the public informed about reconstruction activities.

■ STRUCTURAL EVALUATION

To assist in a uniform evaluation of damaged structures, the Department of Public Works of the DDF (federal district) has developed a standardized procedure. *First*, they have divided the responsibilities between the DDF and the *delegaciones* (wards) for monitoring damage assessment and reconstruction. Public Works is in charge of approximately 600 buildings over four stories in height with major damage. The *delegaciones* are responsible for decisions regarding the approximately 2000 structures less than four stories with significant damage. *Second*, Public Works has compiled a list of 400 structural engineers and architects to be used by building owners to conduct damage assessments. By using only the approved names on this list, Public Works hopes to avoid potential conflicts of interest and problems of credibility. *Finally*, in order to apply the same criteria to all buildings in determining structural damage, Public Works developed, in conjunction with a team of Japanese experts, a standard evaluation form. This form contains detailed evaluation criteria to be used in determining if a building should be demolished or if (and how) it can be repaired.

■ DEMOLITION

By mid-December, 7,400 damaged buildings had been identified with 775 in a state of partial or complete collapse requiring demolition. A decision was made to use explosives to implode the larger buildings in the central part of the city requiring demolition. These explosions take place only on Sundays and will of necessity proceed at a slow pace. By January 12, 1986 it is expected that thirty buildings will have been demolished in this manner. The government has stated that all demolition needs to be completed by March 31, before Mexico City hosts the World Cup Soccer Championship. At some of the locations of cleared building sites (particularly government buildings) the government has provided what are popularly referred to as "instant parks", complete with landscaping, benches, and lamps. These parks also serve to meet a goal of the government to provide more green space in the center of the city.

■ DEBRIS REMOVAL

Debris removal posed a major problem for Mexico City after the earthquake. In the first days it was removed primarily at night from the collapsed building sites because of the city's enormous daytime traffic problems. It is being used for landfill at several sites and there are some proposals for parks and housing developments on these sites. The government is also encouraging the recycling of building materials, including concrete blocks and steel. In the low-income residential communities, residents have salvaged all possible building materials, ranging from bricks to whole window and door frames.

■ REBUILDING

An emergency building code is in place to govern rebuilding and construction already in progress at the time of the earthquake. One of the committees of the Reconstruction Commission is preparing recommendations for a new code that should be ready by October 31, 1986. Microzonation studies are

also underway to provide more information on the soils underlying Mexico City.

■ **EXPROPRIATION**

To help create sites for rebuilding housing, a significant problem after the earthquake, the President issued an expropriation order for 7,000 properties in early October. These properties were primarily housing units that were seriously damaged in the earthquake. The intent of the expropriation was to insure that the government, by owning the land, would be able to provide low cost housing to residents. However, since the expropriation was done in haste, errors were made and a number of appeals for exclusion were filed by landowners. At the same time, the tenants of some unexpropriated residential properties have appealed for inclusion in this measure in an effort to secure their land title and speed the process of rebuilding.

■ **HOUSING**

As many as 30,000 housing units were lost and 60,000 damaged in Mexico City in the September earthquake and aftershock. A major problem in the provision of new housing is the estimated 600,000 unit shortage of housing that existed prior to the earthquake. Three programs have been implemented to rebuild and upgrade housing. *First,* the government established a subcommittee of the Reconstruction Commission to develop a rebuilding program to be coordinated through the Housing Renovation Program. This program announced on Christmas Day that it had distributed 10,000 "right-to-housing" certificates to homeless families which qualifies them for one of the government built-units. *Second,* a large number of non-governmental organizations have developed programs in the low-income neighborhoods to assist in housing construction by offering financial and legal assistance, building materials at subsidized cost and construction advice. These organizations have begun to coordinate efforts among themselves as well as with the official government effort. *Third,* many neighborhood groups in the low-income communities have initiated self and community-help programs in repairing, rebuilding and constructing housing.

■ **DECENTRALIZATION**

Prior to the earthquake the government recognized the need to decentralize major government and private sector operations. The loss of government buildings and functions provided additional impetus to the decentralization effort. A decision was made to disperse specialized medical training throughout the country, and the Departments of Fisheries and the Navy have been relocated to sites along the coast. Some private businesses, particularly in the heavily damaged textile businesses, are considering relocation to sites outside the central city.

Photo: P. Schulz

"INSTANT" PARK AT CLEARED SITE OF A COLLAPSED BUILDING

- **FINANCING THE EFFORT**

An enormous problem in the reconstruction effort is the question of funds. It has been estimated that the earthquake caused $4 billion worth of damage. This is in addition to a pre-existing $96 billion foreign debt, a 60% annual inflation rate, and a severe austerity program instituted by the national government. Immediately after the earthquake a reconstruction fund was established by the government. Many non-governmental organizations, and foreign governments have contributed assistance. However, this fund is adequate to cover only a fraction of the costs of reconstruction. It is not clear at this time how the costs associated with recovery will be covered. The Financial Affairs Committee of the Reconstruction Commission has submitted a proposal to Congress for a temporary increase in several taxes, including new automobiles, telephone service, profits, and production and services, but no decision on funding mechanisms have been made.

- **PSYCHOLOGICAL IMPACT**

Another aspect of recovery that has proved to be extremely important in Mexico City is the psychological healing and recovery that has to take place. Many people reported feeling particularly vulnerable and helpless after the second earthquake, the large aftershock on September 20. Children were particularly fearful and traumatized and schools have been deluging government and voluntary organizations with requests for training on how to deal with children's fears. In addition to victims, rescue workers have also been experiencing serious psychological problems. Psychological counseling is being offered in the neighborhoods through a variety of programs and some private businesses have offered counseling through their personnel offices. After the earthquake UNICEF organized volunteer psychologists and pyschiatrists in a "train-the-counselor" network. Within weeks several hundred counselors and para-counselors began providing services throughout the city.

A CHECKLIST FOR RECOVERY ACTIONS

The most effective recovery plan must include elements developed prior to the earthquake. Public and private organizations need to consider:

- Is there a plan to organize the recovery -- such as a suggested recovery authority with functions and possible assignments?
- Will special ordinances and legislation be required? Have such ordinances been drafted?
- Are there plans for assuring the continuance of government and business functions? Such contingency plans should assume the possible loss of records, supplies and inventories as well as of building space.
- Are there plans for providing immediate disaster assistance, such as temporary housing, mass feeding, financial assistance, and psychological counseling to victims and families of victims?
- How will public information needs be handled? Are there procedures to help people locate the missing? Are there procedures to notify employees whether and where to return to work?
- Are there plans for hazard abatement e.g. to inspect, post, close and demolish hazards that are a threat to public safety?
- Is there a plan to document and tally costs associated with the earthquake? Such information will be needed to substantiate insurance claims and disaster assistance requests, and to speed payment to vendors and mutual aid partners.

Effective pre-earthquake hazard mitigation and preparedness measures will facilitate the most efficient recovery. This calls for reducing earthquake risks by such steps as regulating new construction, rehabilitating hazardous buildings, careful land use and siting decisions, reducing nonstructural hazards in residences and workplaces, storing emergency supplies, and developing individual as well as organizational preparedness and response plans.

BAREPP: EARTHQUAKE PREPAREDNESS FOR THE BAY AREA

The threat of major and damaging earthquakes in California is a fact.

How we respond to that threat is a concern shared by many local, state, federal, volunteer and private sector organizations.

The BAY AREA REGIONAL EARTHQUAKE PREPAREDNESS PROJECT (BAREPP) promotes comprehensive earthquake preparedness actions by these organizations and provides technical and planning assistance for a variety of programs.

This special issue of NETWORKS has been published as an information service to Bay Region organizations concerned with earthquake preparedness.

STAFF
EDITOR.....JIM BRADY
DIRECTOR.....RICHARD EISNER
DEPUTY DIRECTOR.....PAULA SCHULZ
PROJECT PLANNER.....MARJORIE GREENE
STAFF GEOLOGIST.....ED BORTUGNO
RESEARCH ASSOC.....JELENA PANTELIC
CLERICAL.....SUSAN BONINO

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BAREPP

BAY AREA REGIONAL EARTHQUAKE PREPAREDNESS PROJECT

METROCENTER
101 8TH STREET, SUITE 152
OAKLAND, CA 94607
(415)540-2713

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